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Notes on Trichomanes—I. The identity of Trichomanes pyxidiferum L.

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(WITH PLATES 30 AND 31)

The genus *Trichomanes* as included by Linnaeus in his "Species Plantarum" contains eleven species of the genus as now understood, in addition to certain species now included in *Hymenophyllum* and *Davallia*. The first species mentioned is *Trichomanes membranaceum*. But Linnaeus had previously established the genus as a monotypic one based on Plumier's *pl. 86.** This plate represents *Trichomanes crispum*, which must thus be regarded as the type of *Trichomanes*.

Since Linnaeus's time many subdivisions of the genus have been made and some raised to generic rank. It is not proposed to enter into a discussion of the validity of these groupings in these "Notes." The genus *Trichomanes* is here referred to in its widest sense. Nor is it proposed to undertake a monograph of the genus or any of its subdivisions. To do so would be a somewhat tremendous undertaking, as those who have attempted to sort out even a few of the species will agree. The genus is in a chaotic state. The chief reason for this is the large number of descriptions of species that have been published without illustration. With plants of this nature, accurate figures of some sort accompanying specific descriptions are in many cases a necessity; it is often practically impossible to furnish a written description that will apply to one species and to one alone.

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* Gen. Pl. 20. 1737; also Hort. Cliff. 476. 1737.

In this state of affairs all attempts to fix upon the oldest name for any species of the genus, excepting Linnaean species, must be temporarily given up. We have first to see if the current idea of the plant may not be erroneous, and if the plant can be definitely pinned to a given name. During the last three years I have been fortunate enough to obtain for examination, mostly through the kindness of European botanists, types of various species, and to have had for comparison with such adequate plates of published species as do exist, a large collection of tropical American plants, including the collections at the New York Botanical Garden, and many specimens from the United States National Museum at Washington which Mr. William R. Maxon has kindly allowed me the privilege of examining. In these "Notes" photographs of these types will be published, and old plates reproduced side by side with photographs of herbarium specimens when it appears that the identity of any species has been misunderstood and can be definitely fixed upon in this way. This should give part of a foundation for a future revision of the genus. Photographs, when sufficiently enlarged, do not mislead. A beginning in this direction has already been made by others. The most notable instance is Dr. Carl A. M. Lindman's excellent paper, "Remarks on Some American species of *Trichomanes* sect. *Didymoglossum* Desv.",* which may well serve as a model. Dr. Lindman's fine illustrations are drawings made by the aid of a camera lucida, not photographs, but I have preferred photography as sometimes bringing out characters the eyes may overlook.

The subject of the present paper is the identity of *Trichomanes pyxidiferum* L.

Linnaeus's description of this species reads as follows:†

"*pyxidiferum* 5. TRICHOMANES frondibus sub-bipinnatis: pinnis alternis confertis lobatis linearibus.
Filix pyxidifera. *Plum. fil.* 74. *t.* 50.
Dareae tunbrigensis facie. *Pet. fil.* 104. *t.* 13. *f.* 13.
Habitat in America."

Plumier's plant was from Santo Domingo. The locality of

* Ark. Bot. 1: 7–55. 1903.
† Sp. Pl. 1098. 1753.

Petiver's is not stated, except as America, but his figure points unmistakably to the same plant as Plumier's.

This species has been variously interpreted, no doubt often correctly, but probably the most common idea of it is that based on Hedwig's plate* and description. These represent a distinct easily recognizable and common tropical American species, but a recently received specimen of quite another plant from Santo Domingo makes it appear that the latter must bear the Linnaean name. A leaf of this plant, collected on rocks near Constanza, at an altitude of 1,250 meters, March 19, 1910, by H. von Tuerckheim, No. 3069, is figured on PLATE 30, FIG. 2, together with a reproduction of a leaf from Plumier's plate, FIG. 1. It will be seen that the most notable characteristics of the two leaves, the flexuose rachis, the stiff short wide pinnae, and especially the conspicuously short broad almost inflated indusium, appear in both.

This is the plant described by Christ as *Trichomanes junceum.*† His type is from Costa Rica, collected by Wercklé, and specimens so collected, from Christ's Herbarium and now in the Underwood Herbarium at the New York Botanical Garden, agree exactly with the Von Tuerckheim plant. Two leaves from these Costa Rican plants are figured on PLATE 30, FIG. 3.

Christ cites also *Pringle 3800* from Mexico, and a leaf from this number, collected on "faces of damp rocks, Tamasopo Canyon, State of San Luis Potosi, 17 July, 1891," is figured on PLATE 30, FIG. 4, as showing a still more marked resemblance to the Plumier plate. Christ's description of his plant is reprinted below. It will be seen that his idea of *Trichomanes pyxidiferum* is of quite a different species, exactly what does not appear, but most likely the plant of Hedwig's.

"8. Trichomanes junceum n. spec., typ. in Herb. Christ.

"E sectione *T. pyxidiferi* L.

"Differt ab illo statura rigida valde elongata contorta, laciniis angustissimis, urceolis minimis recte patentibus sive recurvis. Habitu Cystosirae angustissimae comparandum, colore nigrescente.

"Rhizomate repente duro 3 mm. lato squamulis patentibus nigris dense vestito, stipite basi incrassato iisdem squamulis ves-

* Filices Gen. et Sp. *pl.* 3. *f.* 2 *and c.* 1799.

† Bull. Boiss. II. 4: 944. 1904.

tito, 3 ad 4 cm. longo filiformi sed rigido, laminae rachi 10 cm. longa flexuosa, lamina lanceolata pinnis adscendentibus linearilanceolatis ad 4 cm. longis iterum pinnatis laciniis linearibus ⅔ mm. latis apice furcatis acutis nervo inconspicuo, urceolis ad basin laciniarum, brevissime pedunculatis patulis sive recurvis 1½ mm. longis anguste conicis vix 1 mm. latis, limbo statu maturo horizontaliter patente receptaculo exserto.

"Plante singulièrement étroite dans toutes ses parties, d'un tissu dur, bien différent du tissu diaphane de *T. pyxidiferum*.

"Hab. Costa-Rica inter muscos epiphyticum. I. Wercklé.

"Obs. Cette forme semble être assez répandue dans l'Amérique centrale. Je l'ai très bien caractérisée du Mexique. I. Pringle 3800 avec la désignation erronée: *T. radicans* Sw. Je l'ai du S. du Brésil. I. Schwacke."

As in many species of *Trichomanes*, the leaf-segments in this plant vary in width, sometimes becoming very contracted, giving the plant a still stiffer look. A curious line parallel with the margins, resembling a false vein broken at intervals, is to be seen in the dried leaves by transmitted light,* but disappears on soaking them in water.† It seems to be formed by some contraction of the leaf-tissue. A note evidently referring to this, on the labels of some of H. H. Smith's plants, reads "the streaks parallel with the veins are a constant character," so it may be they appear also in living plants.

Additional specimens of *Trichomanes pyxidiferum* are in the Underwood Herbarium, as follows:—

CUBA: "Cuba Orientale," *Wright 1807*, *906* in part, *907* in part.

JAMAICA: "Old England," below Cinchona, 1070 m. alt., *Underwood 1666*.

MEXICO: moist virgin forest, 1524 m. alt., *W. A. Murrill & Edna L. Murrill 35;* without locality, *Fred Müller 400*, *Sartorius*.

PERU: near Tarapoto, *R. Spruce 4761;* without locality, *Matthews*.

COLOMBIA: rather rare on trees, damp forest, Sierra del Libano, 1524–1828 m. alt., *H. H. Smith 2255;* on trees and rocks, damp

* See PLATE 30, FIG. 5. A magnifying glass showed this also in the original photograph of FIG. 3.

† See PLATE 30, FIG. 6.

forest, Sierra de Onaca, 1070–1930 m. alt., *H. H. Smith 2443*, in part.

BOLIVIA: San Juan, 1161 m. alt., *R. S. Williams 1207*.

AFRICA: Perie-Wald, Capland, 600 m. alt., *O. Kuntze*.

The question now comes up, what is Hedwig's plant? The earliest name for this that I have been able to fix upon so far with any degree of certainty is *Trichomanes hymenophylloides*, the name given by Van den Bosch in 1863 to his *T. leptophyllum*,* which is a homonym of *T. leptophyllum* A. Cunningham. Van den Bosch's publication of his *T. leptophyllum* reads as follows: "*T. leptophyllum*. *T. pyxidiferum*. Hook. & Grev. tab. 206; Hook. sp. fil. 1, p. 121 (fide specim.)

"Hab. St. Vincent! Martinique! Guadeloupe! Jamaica! St. Domingo! Cuba!"†

Hooker and Greville's plate 206 and the long and careful accompanying description are based on specimens from St. Vincent, collected by the Rev. L. Guilding. These specimens I have not seen, but the plate and description agree well with a large series of specimens from St. Vincent and other parts of tropical America. These specimens in turn connect this plate with that of Hedwig's, which represents a less mature and more contracted leaf-state of the plant than Hooker and Greville's.

Both plates are reproduced in part on PLATE 31 of this paper, together with photographs of leaves of specimens from Santo Domingo and Jamaica.

It is scarcely necessary to reprint here Hooker & Greville's description. The essential points of it, the characteristics by which the plant differs from the plant I refer to true *T. pyxidiferum*, will be seen on PLATE 31. These are: the more slender almost delicate character of the leaf; the straighter more slender rachis; and, most conspicuously, the shape of the indusium. This, instead of being short and broad, has a long slender tube and a suddenly flaring mouth. The amount of leaf-tissue on either side of this indusium varies, even in the same leaf, as will be seen from FIG. 4. It is considerably greater in Hooker & Greville's figure than in Hedwig's, as might be expected from a figure representing, as has already been stated, a much more mature and luxuriant

* Ned. Kr. Arch. 5³: 209. 1863.

† Ned. Kr. Arch. 4: 363. 1859.

form of the plant. Hooker and Greville, commenting upon the indusium in relation to Plumier's plant, with which they supposed theirs to correspond, write: "A remarkable character is described by Plumier in the fructification of this plant; for the fronds, he says, are 'garnies la pluspart, dans le fond de leur découpure, d'une petite boëte, ou calice, rempli de plusieurs vesicules, et scelé par un couvercle garni d'un petit poil dans le milieu.' Now that the involucres should be closed by a convex lid, through which the columella is continued, we consider to be a circumstance impossible in the genus: but we can very well believe that, to an eye unassisted by the microscope, the large expanded and entire (not two-lipped) mouth of the involucre may have the appearance of a lid. And this dilatation of the mouth of the involucre is more remarkable than in any other species of the genus we are acquainted with. We shall be happy if other botanists concur with us in this opinion, and thus determine with tolerable satisfaction the identity of a species, which no one seems to have understood since the time of Plumier." In this connection it may be stated that in dried specimens, at least, of the plant I refer to *T. pyxidiferum*, the indusium, while not strictly two-lipped, is at first bent inward at the apex in a falsely two-lipped fashion, the two edges pressed close together except where the "columella" pushes through, so that it resembles a saccate involucre closed by a sort of convex top, although, of course, this cannot be called a "lid" in any strict sense of the word. No "streaks" or "lines," similar to those I have described in leaves of *T. pyxidiferum*, occur in *T. hymenophylloides*.

Specimens of *T. hymenophylloides* are in the Underwood Herbarium, as follows:—

PORTO RICO: Maricao, *F. L. Stevens 1987;* El Gigante, *F. L. Stevens 1512;* on tree fern, Monte Cerrote, near Adjuntas, 900–1050 m. alt., *Britton & Brown 5426;* on tree fern, between Adjuntas and Jayuya, Arroyo de los Corchos, 800–900 m. alt., *Britton, Cowell & Brown 5267a;* creeping on tree trunks in forest, Rio Prieto and adjacent hills, Sierra de Naguabo, 910 m. alt., *J. A. Shafer 3622;* on dripping wet rocks, Rio Prieto and adjacent hills, 690–1,035 m. alt., *J. A. Shafer 3597;* on rocks in mountain forest, Alto de la Bandera, near Adjuntas, *Britton & Shafer 2070.*

HISPANIOLA: Province of Barahona, Santo Domingo, *Fuertes 1511.*

CUBA: slopes and summit of El Yunque, near Baracoa, 304–608 m. alt., *Pollard & Palmer 158a* in part.

JAMAICA: Morce's Gap, 1493 m. alt., *W. Harris Fl. Jam. 7114;* trail from Vinegar Hill to Mabess River, *Underwood 1253;* Mabess River, below Vinegar Hill, 912 m. alt., *Underwood 1260* in part, *1263;* near Cuna-Cuna Pass, 820 m. alt., *Underwood 2726;* Maybess River, *George L. Fisher 43;* Morce's Gap, *George L. Fisher 110;* vicinity of Morce's Gap, 1,500 m. alt., *W. R. Maxon 2764;* without locality, *Jenman, Wilson.*

GUADELOUPE: without locality, *Madiana;* various localities, *Duss 4436* in part, *4297, 4298.*

MARTINIQUE: Bois de la Calebasse, 360–810 m. alt., *Duss 4059;* Bois du Lorrain, 350–800 m. alt., *Duss 1627.*

DOMINICA: Mt. Diablotin, *F. E. Lloyd 864;* Laudat, *F. E. Lloyd 347, 147;* Hempstead, *F. E. Lloyd 649.*

ST. KITTS: on trees in forest, Belmont, *Britton & Cowell 401;* on trees in forest, Wingfield Estate, *Britton & Cowell 452.*

MONTSERRAT: Pond Mountain, near Rocbes, 610 m. alt., *Shafer 780;* Chaner's Mountain, 610 m. alt., *Shafer 776.*

GRENADA: without locality, *Jenman;* without locality, *Sherring;* Grand Etang, St. Georges, *W. E. Broadway.*

ST. VINCENT: forest, upper Richmond and Wallibon Valleys, on trees, 456–547 m. alt., *H. H. & G. W. Smith 1724;* without locality, *H. H. & G. W. Smith 61.*

TRINIDAD: without locality, *Jenman;* without locality, *Fendler 143, 145.*

MEXICO: moist virgin forest, 1524 m. alt., *W. A. & E. L. Murrill 38.*

GUATEMALA: Pensamalá, Depart. Alta Verapaz, 1161 m. alt., *H. v. Tuerckheim 949.*

COLOMBIA: damp forest, especially glens, near streams, common on trees, logs and rocks, Las Partidas, 1070 m. alt., *H. H. Smith 2256;* on rocks by stream, damp forest, Sierra del Libano, 1828 m. alt., *H. H. Smith 2442;* damp forest, common on trees, Sierra de Onaca, 760–1980 m. alt., *H. H. Smith 2443* in part.

ECUADOR: Andes, *R. Spruce 5355.*

NEW YORK BOTANICAL GARDEN

Description of plates 30 and 31

PLATE 30

TRICHOMANES PYXIDIFERUM L.

FIG. 1. Reproduction of part of *pl. 50*, Plumier's Traité des fougères de l'Amérique. Paris. 1705.

FIG. 2. Leaf from Santo Domingo, *H. v. Tuerckheim 3069*, natural size.

FIG. 3. Leaf from Costa Rica, *Wercklé*, natural size, authentic specimen of *T. junceum* Christ from Christ's herbarium.

FIG. 4. Leaf from Mexico, *Pringle 3800*, natural size, referred by Christ to *T. junceum*.

FIG. 5. Part of a dried sterile leaf from specimen shown in FIG. 2, enlarged.

FIG. 6, Part of a fertile leaf from specimen shown in FIG. 2, after soaking in water, enlarged.

PLATE 31

TRICHOMANES HYMENOPHYLLOIDES Van den Bosch

FIGS. 1, 3, 4. Reproduction of part of *pl. 206*, Hooker & Greville's Icones filicum. London. 1831. FIGS. 1, 3. Fertile leaves. FIG. 4. Portion of a fertile leaf, enlarged.

FIGS. 2 and *c*. Reproduction of part of *pl. 3*, Hedwig's Filicum genera et species. Leipzig. 1799.

FIG. 5. Leaf from Santo Domingo, *Fuertes 1511*, natural size.

FIG. 6. Leaf from Jamaica, *Underwood 1260*, natural size.

FIG. 7. Part of a fertile leaf from specimen shown in FIG. 5, enlarged.

Ruppia anomala sp. nov., an aberrant type of the Potamogetonaceae

C. H. Ostenfeld

(with plate 32)

Ruppia anomala sp. nov. Habitu fere ut *R. maritimae* subsp. *rostellatae*. Caulis filiformis, ramosissimus; folia filiformia; pedunculus post anthesin brevis nec elongatus, rectus; thecae antherarum subglobosae; pollinis cellulae semilunariter curvatae; carpidia 2–4, oblique ovoidea; stigma peltatum, supra visum subrotundum; carpella fructifera oblique ovoidea, apice breviter et oblique attenuata, a basi concreta divergentia; carpellorum podogyna in unum conjuncta; podogynum commune striis longitudinalibus conjunctionem demonstrantibus constructum, sursum incrassatum.

Praecipue differt ab omnibus *Ruppiis* carpellis fructiferis basi concretis, in apice podogyni communis positis.

Porto Rico: border of Lake Guanica, March 11 and 12, 1913, *N. L. Britton & J. A. Shafer 1870*.

In December, 1913, I visited the New York Botanical Garden and studied the collections of the so-called "sea-grasses." In the herbarium material I found a strange plant, habitually like a slender *Ruppia*, but with quite different fruits. I pointed out to Dr. N. L. Britton that this plant, which he had himself collected at the border of a lagoon, Lake Guanica, in Porto Rico, was an unknown plant, at least to me. He then asked me to examine it more closely and, if new, to describe it, and after my return from the West Indies I had the material sent to Copenhagen for study.

I thought at first that we had to do with a new genus, but now I consider it better to regard the plant in question as an aberrant species of *Ruppia*.

The morphology of the stem and leaves is the same as in an ordinary slender and tiny *Ruppia maritima* L.* Also the morphology of the *flower* is in all essential points as usual. Each of the two stamens consists of two anther halves (thecae)

* See, for example, Graves, A. H. The morphology of *Ruppia maritima*. Transact. Connecticut Acad. **14**: 59–170. *pl. 1–15*. 1908.

and a connective with an outgrowth of a conical shape; the thecae are round-ovoid with a slight furrow indicating their two sacs. The pollen grains are of the same bow-shaped form as in *R. maritima* and with the same delicate reticular thickenings of the outer surface (see Graves, *pl. 12*). The female part of the flower consists of two or four pistils of oblique-ovoid form and with a peltate sessile stigma. The ovule and the integuments do not show anything remarkable, and the finer study of the development of the megasporangium was not possible owing to the fact that the material available was all herbarium specimens.

The peculiarity of the plant does not show itself before we come to the fruit. The peduncle does not lengthen to any evident degree after the fertilization; it remains short as in the subsp. *rostellata* (Koch) Asch. & Graebn. of *R. maritima*. The main point of distinction between our new species and the others is the development of the stipe of the fruit. In *R. maritima* and other species each sessile pistil after fertilization grows out to a stipitate fruit, thus forming four free and distinct drupelets which are long-stalked in most species, but short-stalked in the var. *brevirostris* Agardh of *R. maritima*. In our new species the stipes of the drupelets are united into one common stipe (a podogynium), upon which four longitudinal furrows show the lines of concrescence. At the top of the podogynium the drupelets are placed in a star-like manner; their form does not show any essential difference from that of the drupelets in *R. maritima*. The length of the podogynium varies much, sometimes it is very short, not reaching that of the drupelet, sometimes it is nearly twice as long; but it does not reach such dimensions as the stipes of the free drupelets in *R. maritima*.

Very often only one or two pistils are fertilized, and we then find the abortive pistils as small warts at the top of the podogynium. The concrescence of the stipes goes on in spite of the abortion of some of the pistils; but the podogynium seems to remain shorter in the cases where only one drupelet has been developed.

I have had plenty material at hand, and the development of the fruit has been the same in all specimens seen. Otherwise I would have considered it as a teratological abnormity; now I must regard it as the normal state of this plant. It places the species

in a very remote place in the genus, and even in the whole family of *Potomogetonaceae*, of which one of the main characters is the distinct and free carpels.

As I have not collected the plant myself, I do not know if the conditions of life are in any regard peculiar; it may be that a closer study of the plant in its natural environment will elucidate the mystery which always seems to lie behind such a case where a plant being like a common species in most respects differs in one essential point. This new species of *Ruppia* has an analogue in the famous *Capsella Heegeri* Solms,* which only differs from the common *Capsella Bursa-pastoris* L. in the shape of the fruit, a character which would remove it from the genus *Capsella* and from the group of genera to which *Capsella* belongs, if purely formal reasoning was used.

It is possible that *Ruppia anomala* has sprung from *R. maritima* in a similar manner to that supposed to have been the case when *Capsella Heegeri* was found on the drill-ground at Landau in Germany. It is to be hoped that some botanist will be able to visit Lake Guanica and study the *Ruppia* in a more thorough manner than I have been able to do. Perhaps he will clear up the matter; at present we have only to consider it a new and aberrant species.

NOTES

After the manuscript of this article was sent to America for publication, Dr. N. L. Britton informed me that he had visited Lake Guanica again this year and had collected a *Ruppia* which he was sending me for examination. When this material arrived it was at once evident that we had to do with the widespread *Ruppia maritima*. The specimens were in flower and fruit and showed elongated, partly coiled peduncles and *free* and long-stipitate drupelets, i.e., they were quite typical *R. maritima*, none exhibiting the peculiar characteristics of the plant described above. As to the collecting place Dr. Britton said, "the *Ruppia* came from the same shore of Lake Guanica that the other aquatic plant was obtained from. I cannot say that it was at exactly the same spot, but it must have been within one or two hundred meters." This is a very interesting

* Solms-Laubach, H. Graf zu. Cruciferenstudien I. *Capsella Heegeri* Solms, eine enu entstandene Form der deutschen Flora. Bot. Zeit. **28**: 167. 1900.

observation, and it makes the present case still more parallel to that of the finding of *Capsella Heegeri*. The new form has evidently sprung from the true *R. maritima* at the spot. I will repeat the wish expressed above as to a thorough study of the plant *in situ* and only regret that an experimental study of a plant of this kind would involve considerable difficulty.

In a paper on the postglacial plant-remnants of the moors of Norway, Jens Holmboe* has mentioned (p. 149) and figured (*pl. 2, f. 19*) an anomalous fruit of *R. maritima* in which the two fruitlets were united at their base and supported by one very long common podogynium, thus a case much resembling the fruits of the new Porto Rican species. He says that he found only one fruit of that kind amongst several thousand normal fruits. I owe this reference to Mr. Knud Jessen of Copenhagen.

BOTANISK MUSEUM, COPENHAGEN.

Explanation of plate 32

RUPPIA ANOMALA Ostenfeld

FIG. 1. Part of a plant showing the fruiting stalk. The upper fruit has three well-developed drupelets and a long podogynium, the lower only one well-developed drupelet and a short podogynium. × 2.

FIG. 2. Spike before flowering, showing 2 stamens and 2 pistils in each flower bud (microscope system, Winkel, Ob. 4, Oc. 1).

FIG. 3. Another flower bud from the side (Ob. 4, Oc. 1).

FIG. 4. A pistil showing the position of the egg and its integuments (Ob. 3, Oc. 1).

FIG. 5. A flower after flowering; none of the pistils has been fertilized and no growth has taken place (Ob. 1, Oc. 1).

FIG. 6. A fruit of which one drupelet has developed, the three remaining unfertilized appearing as warts (Ob. 1, Oc. 1).

FIG. 7. Pollen grains (Ob. 6, Oc. 1).

* Planterester i Norske torvmyrer. Kgl. Norske Vidensk. Selsk. Skr. I. No. 2. 1903.

On the distribution and correlation of the sexes (staminate and pistillate flowers) in the inflorescence of the aroids Arisarum vulgare and Arisarum proboscideum

J. Arthur Harris

(with two text figures)

I. Introductory Remarks

Because of its high degree of specialization the inflorescence of the aroids should present most interesting, and in some instances favorable, material for biometric studies.

So far as I am aware, however, practically nothing is known in quantitative terms of variation and correlation in the inflorescence of this group. In this note I present the results of an analysis of the data for two species collected by Cannarella. I hope that the publication of these results will suggest to those who have the opportunity, the desirability of obtaining more adequate series of quantitative data on this group. The structural peculiarities of the Aroids are too well known to botanists to require comment. Those who wish further details for *Arisarum* may consult the well-known monographs by Engler. The two species here considered are figured in Curtis's Botanical Magazine, *pl. 6023, 6634*.

In the case of *Arisarum vulgare* Cannarella* has given data for number of male and female flowers in the inflorescence. These he tables in several different ways, but without bringing out the full significance of the observations. For *Arisarum proboscideum*† he has recorded the data for number of staminate and pistillate flowers per inflorescence for a series of individual habitats. Beyond a descriptive discussion he gives no analyses of these data except to state that the correlation between the number of male and female flowers for the total material is $r = -.069$. A negative value in a character such as the present leads one to suspect arith-

* Cannarella, P. Ricerche intorno di limite di variabilitá dell' *Arisarum vulgare* Torg. Nuovo Gior. Bot. Ital. N. S. **12**: 328–347. 1905.

† Cannarella, P. Ricerche sull' apparato florale dell' *Arisarum proboscideum* Savi. Cont. Biol. Veg. R. Ist. Bot. Palermo **4**: 121–138. 1909.

metical error. As will be shown presently the correlation is not negative but positive in sign, though numerically small. For all details concerning habitats and other biological conditions the original papers must be consulted.

II. STATISTICAL ANALYSIS OF DATA

Consider first the means and variabilities of the number of staminate and pistillate flowers in the inflorescences of the two species. For this discussion only the total materials collected for each species will be used. In *A. vulgare* the range of variation in number of staminate flowers is very great. The classes and the frequency with which they occur, together with the total number of pistillate flowers found on the inflorescences, are shown in TABLE I.

TABLE I

FREQUENCY OF STAMINATE FLOWERS AND ASSOCIATED PISTILLATE FLOWERS IN *A. vulgare*

Staminate flowers	*f*	Total pistillate flowers	Staminate flowers	*f*	Total pistillate flowers
8	1	3	35	41	209
14	1	6	36	37	202
16	1	13	37	37	254
17	1	1	38	30	189
18	3	12	39	39	263
19	2	15	40	21	140
20	1	4	41	26	175
21	4	13	42	21	147
22	3	14	43	11	74
23	8	37	44	14	108
24	13	53	45	6	50
25	9	50	46	5	38
26	23	119	47	2	14
27	14	64	48	4	39
28	16	80	49	3	31
29	31	132	50	2	19
30	33	155	51	1	5
31	30	156	53	1	6
32	37	186	57	3	42
33	33	164	59	1	7
34	50	269	Totals.....	619	3,558

The variation in the number of pistillate flowers may be calculated from the totals of TABLE II. The data for *A. proboscideum* appear in the totals of TABLE III. From these I deduce the constants for number of flowers per inflorescence given in TABLE IV.

The fact that the two species differ greatly in the numbers of the two types of flowers which they produce is well known to taxon-

omists. Any discussion of the differences in the means of the two species would therefore be superfluous. Since the mean numbers are all conspicuously lower in *A. proboscideum* one would naturally expect the absolute variabilities as measured by the standard deviations to be lower also. The constants show that this is actually the case. The coefficients of variation show that *A. proboscideum* is also *relatively* far less variable than *A. vulgare*. The result is rather surprising in view of the fact that the collections of *A. proboscideum* were apparently made from a wider range of habitats than those for *A. vulgare*.

The coefficients of variation for number of pistillate flowers are in both species conspicuously higher than those for staminate flowers. The interpretation of this result presents considerable difficulty. Variation in both cases is so low that a deviation of a unit is relatively far greater than in the case of the staminate flowers. Thus without a full consideration of the statistical difficulties presented by the case one cannot assert that biologically there is a greater tendency to variability in the number of pistillate than in the number of staminate flowers.

TABLE II

CORRELATION IN INFLORESCENCES OF *A. vulgare*

PISTILLATE FLOWERS

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Totals
Staminate flowers:																	
6–10	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	1
11–15	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	1
16–20	1	—	—	4	1	—	—	—	—	1	—	—	1	—	—	—	8
21–25	1	1	13	10	—	5	1	6	—	—	—	—	—	—	—	—	37
26–30	—	2	22	42	23	13	6	7	—	1	1	—	—	—	—	—	117
31–35	—	2	31	54	29	33	18	20	2	—	—	2	—	—	—	—	191
36–40	—	—	7	26	22	35	28	30	7	3	—	4	2	—	—	—	164
41–45	—	—	5	7	9	11	12	17	6	4	1	3	3	—	—	—	78
46–50	—	—	—	—	1	3	2	1	3	1	4	—	—	—	1	—	16
51–55	—	—	—	—	1	1	—	—	—	—	—	—	—	—	—	—	2
56–60	—	—	—	—	—	—	1	—	—	—	—	1	—	1	—	1	4
Totals.....	2	5	79	143	86	102	68	81	18	10	6	10	6	1	1	1	619

The correlation surfaces for the two species are given as TABLES II and III. That for *A. proboscideum* appears in units. For *A. vulgare* the range of variation in number of staminate flowers is so wide that it has seemed desirable to group in classes

of 5 units range. The correlation coefficient for the ungrouped material may be computed from the condensed correlation TABLE I. The correlation constants in TABLE IV are calculated from the ungrouped observations. The first point to be noted is that the less variable inflorescence of *A. proboscideum* shows a distinctly lower correlation between the number of staminate and pistillate flowers than does that of *A. vulgare*. The difference is .226 ± .025, a value 9 times as large as its probable error and so unquestionably significant.

TABLE III

CORRELATION IN INFLORESCENCE OF *A. proboscideum*

	PISTILLATE FLOWERS						
	1	2	3	4	5	6	Totals
Staminate flowers:							
10	—	1	—	—	—	—	1
11	1	—	1	—	—	—	2
12	3	10	—	—	—	—	13
13	5	38	7	—	—	1	51
14	10	105	19	2	2	—	138
15	8	144	81	18	15	—	266
16	8	195	186	55	16	—	460
17	13	304	416	34	14	—	781
18	8	302	218	26	12	—	566
19	3	76	106	29	25	2	241
20	—	49	58	26	20	—	153
21	—	20	36	12	7	—	75
22	—	6	31	6	1	—	44
23	—	6	3	—	1	—	10
24	—	—	1	—	—	—	1
Totals.....	59	1,256	1,163	208	113	3	2,802

If one expresses the results in terms of regression the linear equations are

For *A. vulgare:*

$$p = .3796 + .1560\, s,$$

$$s = 27.205 + 1.252\, p.$$

For *A. proboscideum:*

$$p = 1.0299 + .0955\, s,$$

$$s = 15.836 + .490\, p,$$

where s = number of staminate and p = number of pistillate flowers.

These values are deduced from the ungrouped observations.

For *A. vulgare* it seems desirable to calculate regression on the grouped values given in TABLE II. This gives for the correlation

$$r_{sp} = .440 \pm .022,$$

a value differing from that obtained from the ungrouped observations by only about one tenth its probable error. The regression equations are

$$s = 27.065 + 1.274\, p,$$

$$p = .5280 + .1518\, s.$$

These are the lines in the diagram, FIG. 1.

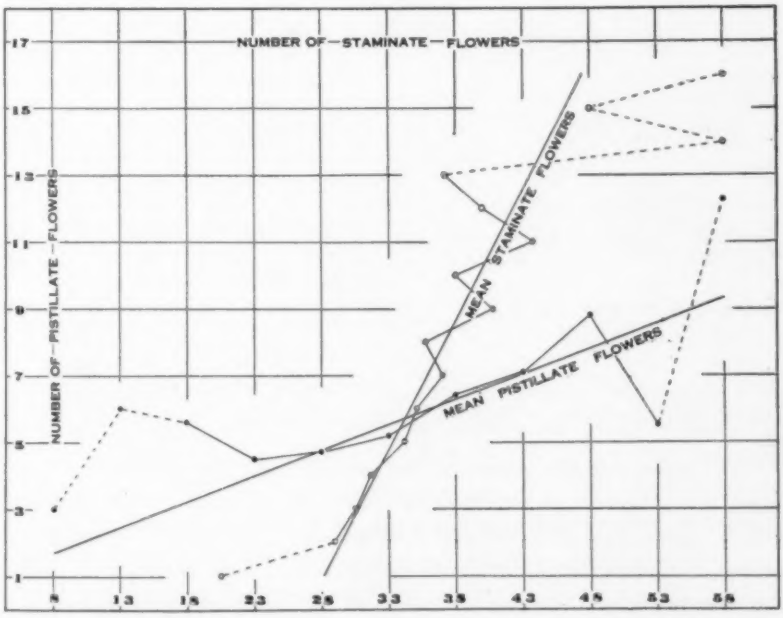

FIG. 1. Relationship between number of pistillate and number of staminate flowers in the inflorescence of *Arisarum vulgare*.—Empirical means and calculated lines.

These diagrams show considerable irregularities in the distribution of the means of the numbers of pistillate flowers associated with different numbers of staminate flowers and *vice versa*. It seems desirable, therefore, to apply a statistical test of the goodness of fit of the straight lines to the empirical means. Calculating

the correlation ratio* and using Blakeman's† well-known criterion

$$\frac{\zeta}{E\zeta} = \frac{\sqrt{N}}{.67449}, \quad \frac{1}{2}\sqrt{\zeta} \cdot \frac{1}{\sqrt{1 + (1 - \eta^2)^2 - (1 - r^2)^2}}.$$

I find:

	A. vulgare	*A. proboscideum*
Correlation coefficient	.440 ± .022	.216 ± .012
Correlation ratios:		
From means of pistillate flowers	.495 ± .020	.290 ± .012
Blakeman's criterion	4.38	7.87
From means of staminate flowers	.486 ± .021	.233 ± .012
Blakeman's criterion	3.96	3.37

TABLE IV

STATISTICAL CONSTANTS FOR *Arisarum*

	For *A. vulgare*	For *A. proboscideum*
Number of staminate flowers:		
Mean	34.402 ± .175	17.143 ± .024
S.D.	6.463 ± .124	1.850 ± .017
C.V.	18.79 ±0.37	10.79 ±0.10
Number of pistillate flowers:		
Mean	5.748 ± .062	2.668 ± .010
S.D.	2.282 ± .044	0.817 ± .007
C.V.	39.70 ±0.87	30.62 ±0.30
Total flowers per inflorescence:		
Mean	40.150 ± .210	19.810 ± .028
S.D.	7.747 ± .149	2.178 ± .020
C.V.	19.29 ±0.38	10.99 ±0.10
Correlation of staminate and pistillate flowers	.442 ± .022	.216 ± .012

The values of Blakeman's criterion all suggest significant non-linearity. The one which may be given the greatest weight is that for the regression of pistillate or staminate flowers in *A. proboscideum*. An examination of the diagram, FIG. 2, shows a peculiar and (on the basis of the data in hand) quite inexplicable periodicity in the distribution of the mean number of pistillate flowers. While the graphs themselves and the critical statistical constants indicate that straight lines do not exactly describe the interrelationship between the two variables, it is impossible to assert from the data as they stand that any curve of a higher order would express the rate of change in the mean value of an associated character

* Pearson, K. Drapers' Co. Res. Mem., Biom. Ser. II. 1905.

† Blakeman, J. Biometrika 4: 332–350. 1905.

better than is done by a straight line. Such deviations as do occur are probably due for the most part to the unavoidable errors of sampling. At any rate, the discussion of this point cannot be carried farther without more adequate biological information.

It is interesting to examine the results obtained for each of the sub-habitats from which *A. proboscideum* was collected.* These are the data combined to form our TABLE III.

The results for correlation between number of staminate and pistillate flowers, r_{sp}, are given in the third column of Table V. With but two exceptions the correlations are positive in sign. These two exceptional cases show very substantial negative coef-

TABLE V

CONSTANTS FOR INDIVIDUAL CORRELATIONS OF *A. proboscideum*

Locality	Number of plants	r_{sp}	r_{sp}/E_r	r_{ts}	r_{to}	r_{to}/E_r
Ospedallette	341	+.331±.033	10.19	+.922	−.413±.030	13.68
Picarelli	490	+.245±.029	8.55	+.876	−.482±.023	20.59
Scierta	465	+.090±.031	2.89	+.951	+.005±.031	.16
Zigarelli	48	+.290±.089	3.25	+.944	−.291±.089	3.26
Contrada	80	+.276±.070	3.96	+.981	+.123±.074	1.65
Ajello	13	−.422±.154	2.74	+.952	+.399±.157	2.53
Faliari	500	+.187±.029	6.42	+.927	−.209±.029	7.26
Lareto	685	+.106±.026	4.17	+.915	−.181±.025	7.27
Liquerini	16	−.566±.115	4.94	+.588	−.206±.161	1.28
Montefredani	164	+.077±.052	1.47	+.921	−.124±.052	2.38

ficients, which are apparently significant in comparison with their probable errors. Since the number of individuals is so small—only 13 and 16—the conventional method of computing the probable error can not be given too much weight. The two exceptions to the rule cannot, therefore, be regarded as a real argument against the general existence of a positive correlation. The average value of these correlations, obtained by weighting with the numbers of individuals upon which the several coefficients are based, is $\bar{r} = +.170$. The difference between this value and the $r = +.216$ obtained from the whole (massed) material gives some idea of the influence of heterogeneity on the magnitude of the correlation.

Consider now the relationship between the total number of flowers produced per inflorescence and the relative numbers of the

* The numbers are in some cases far too small to give trustworthy constants, but it has seemed best to calculate the results for all alike to avoid the possible criticism of selection of data.

two types of flowers in the inflorescence. This seems a question of considerable interest because of the many discussions of the influence of feeding or degree of development on sex.

The problem is approached statistically as follows. Let z

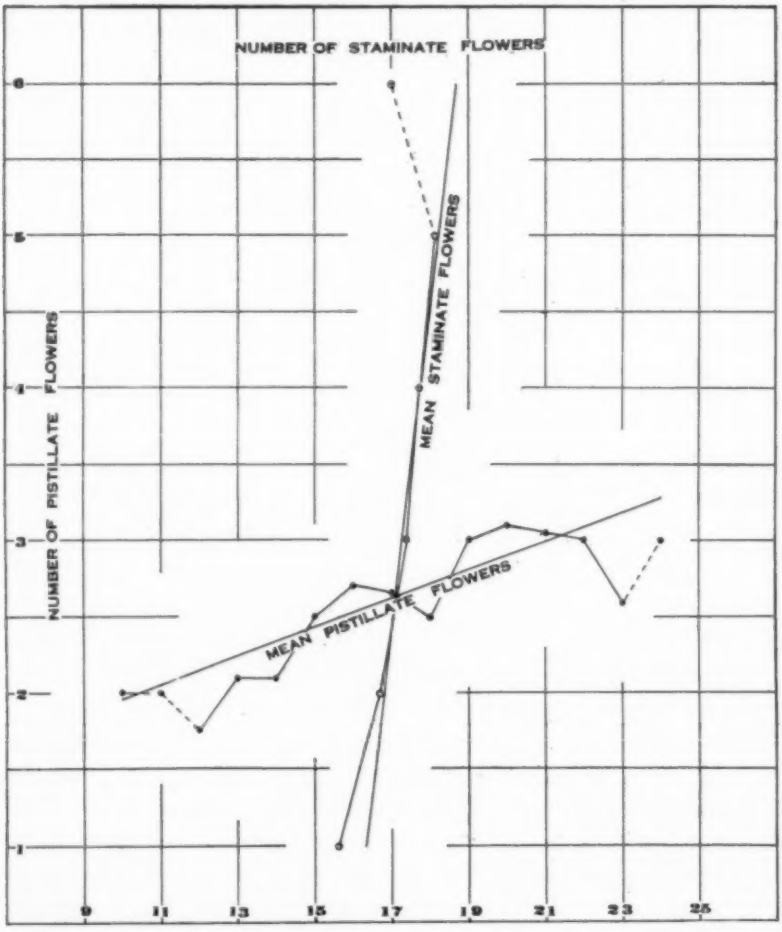

FIG. 2. Regression of number of staminate on number of pistillate, and of number of pistillate on number of staminate flowers in *A. proboscideum*.

represent the deviation of the number of staminate flowers per inflorescence from the probable number on the assumption that the proportion of the two types, s and p, is unaffected by the total number produced per inflorescence. If the correlation between

t, $= s + p$, or total flowers per inflorescence, and z be positive it indicates that as the total number of flowers per inflorescence becomes larger the staminate flowers are relatively more numerous. Using the formula suggested to me* by Professor Karl Pearson I find:

For *A. vulgare*:†

$$r_{tm} = + .964 \pm .002,$$

$$r_{tz} = - .230 \pm .026.$$

For *A. proboscideum:*

$$r_{tm} = + .931 \pm .002,$$

$$r_{tz} = - .234 \pm .012.$$

In both cases the correlation between total flowers and number of staminate flowers is high. This is as one would expect it to be. The interesting feature of the result is that in both species there is a significant *negative* correlation between the total number of flowers and the deviation of the number of staminate flowers from their probable value. In short, the male flowers while absolutely more abundant in the larger inflorescences are there *relatively* distinctly less abundant. Or in other words the larger inflorescences tend to produce a larger proportion of pistillate flowers.

Consider these relationships on the basis of the individual collections.

TABLE V, in which the constants for the individual collections of *A. proboscideum* are given, shows that with a single exception, in which N is very small, the correlations for total flowers and staminate flowers are very high.

The critical values derived from these are given in the sixth column. Of these 10 coefficients, 7 are negative in sign, and 5 may be considered unquestionably significant in comparison with their probable errors. Neither of the 3 positive values may be looked upon as certainly trustworthy. Thus while the constants for the individual sub-series are very irregular in magnitude they fully substantiate the conclusions to be drawn from the constant

* Harris, J. Arthur. The Correlation between a Variable and the Deviation of a Dependent Variable from its Probable Value. Biometrika **6**: 438–443. 1909.

† Calculations from ungrouped data.

for the whole material. The average (weighted) value is $\bar{r}_{tz} = -.223$. This value is not significantly different from the $r_{tz} = -.234$ obtained from the combined materials.

III. SUMMARY AND CONCLUSIONS

As a suggestion for more adequate investigation of variation and correlation in the specialized inflorescence of the aroids this note presents the results of a statistical analysis of two rather large series of data collected for the genus *Arisarum* by Cannarella.

The following points may be emphasized:

In both *A. vulgare* and *A. proboscideum*, the coefficient of variation for number of pistillate flowers is far higher than that for number of staminate flowers. The interpretation of this result presents considerable difficulty.

In *A. vulgare* the inflorescence not only produces a larger number of both staminate and pistillate flowers than does that of *A. proboscideum*, but shows a far higher variability, both absolute and relative.

Apparently the collections of *A. proboscideum* came from a wider range of habitats than those of *A. vulgare*. If this be true, the variability which they show is in part due to heterogeneity arising through environmental differentiation. This probability renders more significant the observed lower variability in *A. proboscideum*. Any subsequent investigation should if possible take into account this factor in drawing comparisons between the variability of these or any other forms.

The inflorescence of *A. vulgare* is not only more variable, but shows a higher degree of correlation of its parts than does that of *A. proboscideum*. In both cases the correlation between number of staminate and pistillate flowers is rather small. The relationship between the numbers of the two types of flowers may be fairly well described by a straight line. The fit of the straight line equations is not altogether satisfactory, but it seems idle to carry the statistical analysis farther on the present data. The effort would much better be expended in securing more adequate biological material.

The correlation between the total number of flowers produced by the inflorescence and the number of staminate flowers is neces-

sarily positive and high. The correlation between the total number of flowers and the deviation of the staminate flowers from their probable value, on the assumption that the character (sex) of the flowers is independent of the size of the inflorescence, is significantly negative. This shows that the larger inflorescences have relatively more pistillate flowers.

COLD SPRING HARBOR,
NEW YORK

Dictyophlois reticulata gen. et sp. nov.

AUG. F. FOERSTE

(WITH PLATE 33)

The name *Stigmaria ficoides* Brongniart at present does service in designating the so-called roots of both of the genera of stems known as *Lepidodendron* and *Sigillaria*. Not only have these roots been found in direct connection with the *Lepidodendron* and *Sigillaria* stems but it has been found impossible so far to discover any specific or generic differences in the roots so connected.

The genus *Lepidodendron* makes its appearance in the Lower Devonian and dies out in the Permian. Recently Dr. David White has called my attention to the fact that in Mississippian or Subcarboniferous specimens of *Stigmaria ficoides* the characteristic round scars, indicating the points of attachment of the so-called rootlets, are distinctly smaller than in Pennsylvanian or Coal Measure representatives passing under the same name.

Students of the microscopic structure of *Stigmaria* and of its rootlet-like appendages, regard the latter as homologous with the monarch roots of certain living plants, so that the main axes of the so-called roots known as *Stigmaria* should be known as rhizophores rather than roots. There is a possibility that these rhizophores represent underground stems, but this still is a debatable question.

In the vicinity of Sample, two miles east of Stephensport, Breckenridge County, western Kentucky, the rhizophores of both *Stigmaria ficoides* and of an undescribed but related genus occur in one of the sandstone layers belonging to the lower part of the Chester division of Subcarboniferous rocks.

The undescribed rhizophores resemble those of *Stigmaria ficoides* in possessing small ring-like areas of attachment of the monarch roots, the latter being arranged in diagonally intersecting rows. In several of these ring-like areas a minute central point could be recognized, but the smaller ring, which in *Stigmaria* intervenes

between this central point and the larger ring, could not be identified with certainty in any case.

These undescribed rhizophores differ from those of *Stigmaria* in having the areas between the ring-like scars of attachment of the monarch roots marked by irregular ridge-like elevations and depressions presenting the appearance of an irregular network. In the immediate vicinity of the ring-like scars the ridge-like elevations of this network tend to be arranged in radiating series. The network evidently is a characteristic of the outer cortex, hence the name *Dictyophlois reticulata*, here proposed for the rhizophores in question. No explanation based on evidence can be assigned at present for the reticulate appearance of the surface of this outer cortex. But, if these rhizophores are homologous with subterranean stems rather than with roots, the reticulate structure may be connected with the former presence of more or less appressed scales, of which, however, there is no positive evidence in *Dictyophlois;* in *Stigmaria* the former presence of appressed scales seems impossible since the outer cortex of the rhizophores in the latter genus is smooth.

The specimens of *Dictyophlois* here described and figured were discovered about ten years ago and were retained in the hope that further evidence regarding their structure might be obtained. Since this delay has not been attended by any additional information the accompanying illustration is published in the hopes that it may arouse interest in other paleobotanists. If *Dictyophlois* is indeed an underground scale-bearing stem then these scales should be found sooner or later still attached to the rhizophores.

Dictyophlois reticulata gen. et sp. nov.

Original diameter of rhizophores varying from 10 cm. to 15 cm. The figured specimen (type) is a flattened fragment 10 cm. in length and 13 cm. in width, exposing a part of one side of a rhizophore, the original diameter of which is unknown. Round areas of attachment of the so-called rootlets usually 3.5–4 mm. in width, but not infrequently attaining a length of 5 mm.; with a small central pit about 0.75 mm. in diameter. These areas are arranged in diagonally intersecting series, five areas occupying a length of 60–80 mm. measured along the diagonal rows. For a distance of 3–4 mm. from the margins of these round areas of attachment the raised ridges forming the intermediate

network tend to be arranged in a more or less radiating manner. In the more distant parts of the intermediate area these ridges form a more irregularly reticulated network. Measured along the crests of the ridges, the meshes of the network frequently attain a length of 3 mm. and a width of 2 mm.; the included space frequently attains a depth of 1–1.5 mm., narrowing toward the bottom, so as to form an irregular funnel-like pit.

Type specimen in the possession of the writer.

KENTUCKY: Sample, Breckenridge County.

DAYTON, OHIO

Explanation of plate 33

DICTYOPHLOIS RETICULATA Foerste

Type specimen, collected at Sample, Breckenridge County, Kentucky. Natural size.

INDEX TO AMERICAN BOTANICAL LITERATURE

1915

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the word America being used in the broadest sense.

Reviews, and papers that relate exclusively to forestry, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included, and no attempt is made to index the literature of bacteriology. An occasional exception is made in favor of some paper appearing in an American periodical which is devoted wholly to botany. Reprints are not mentioned unless they differ from the original in some important particular. If users of the Index will call the attention of the editor to errors or omissions, their kindness will be appreciated.

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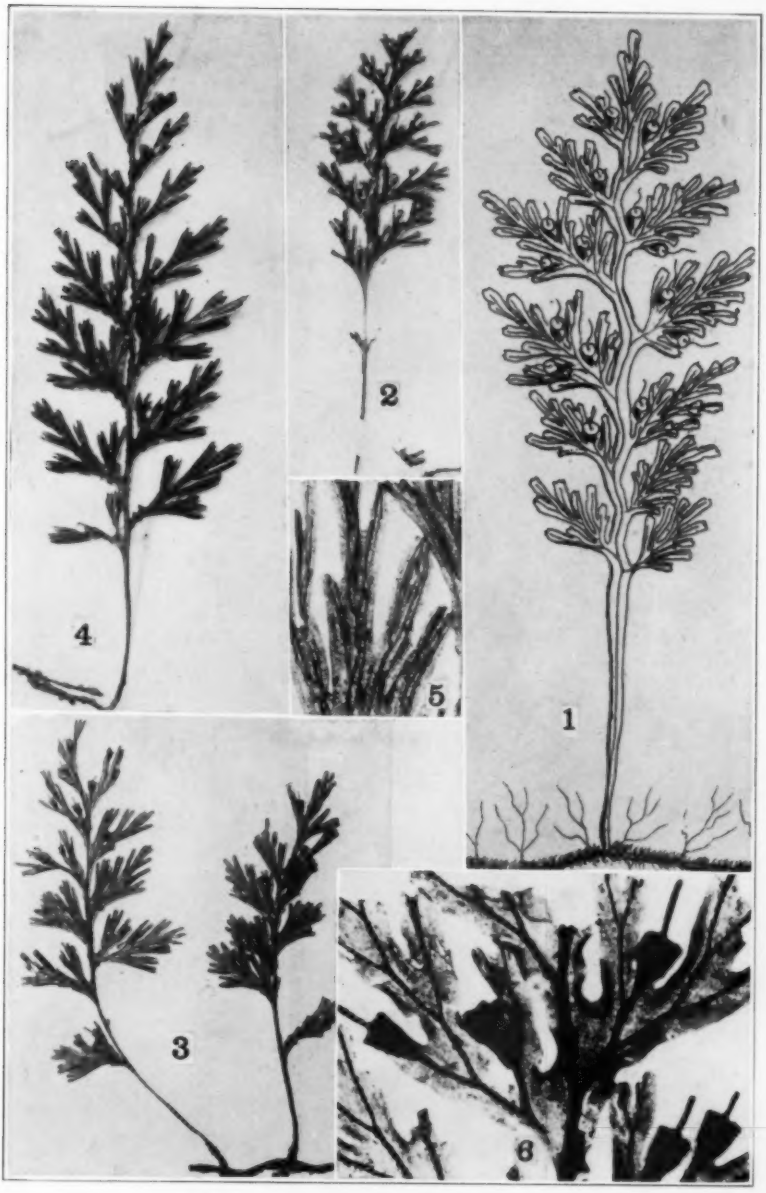

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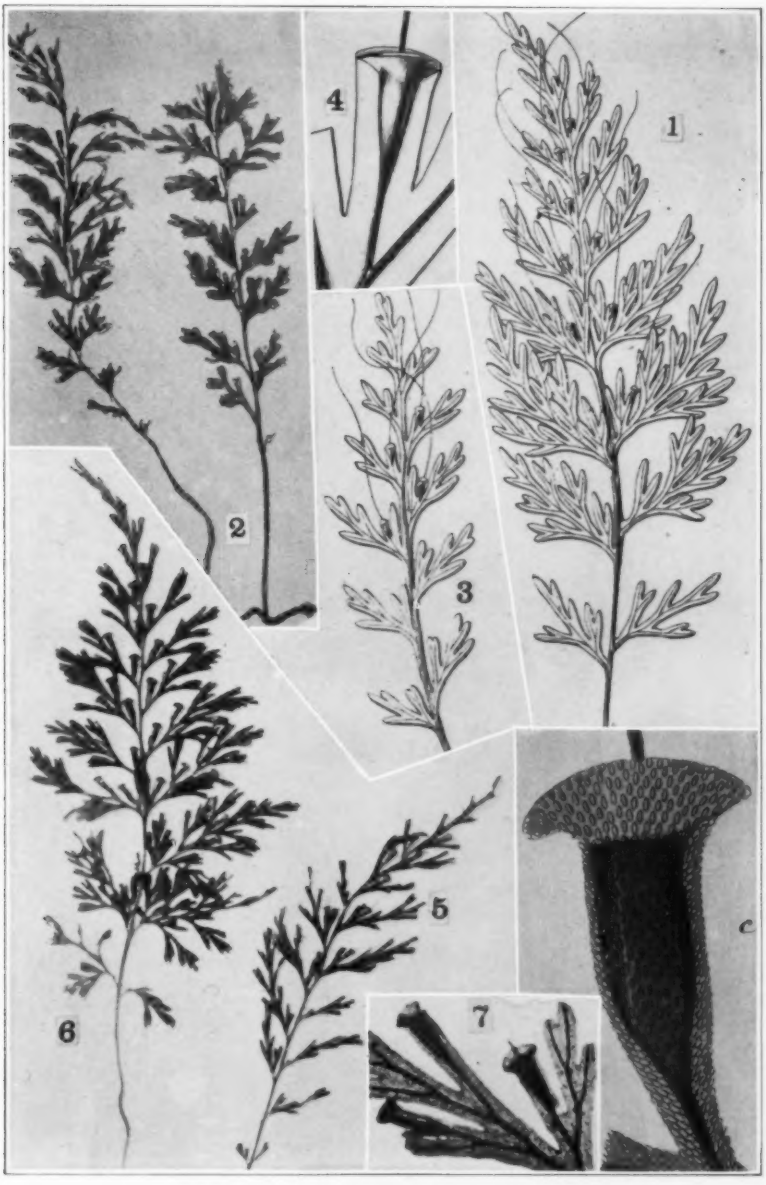

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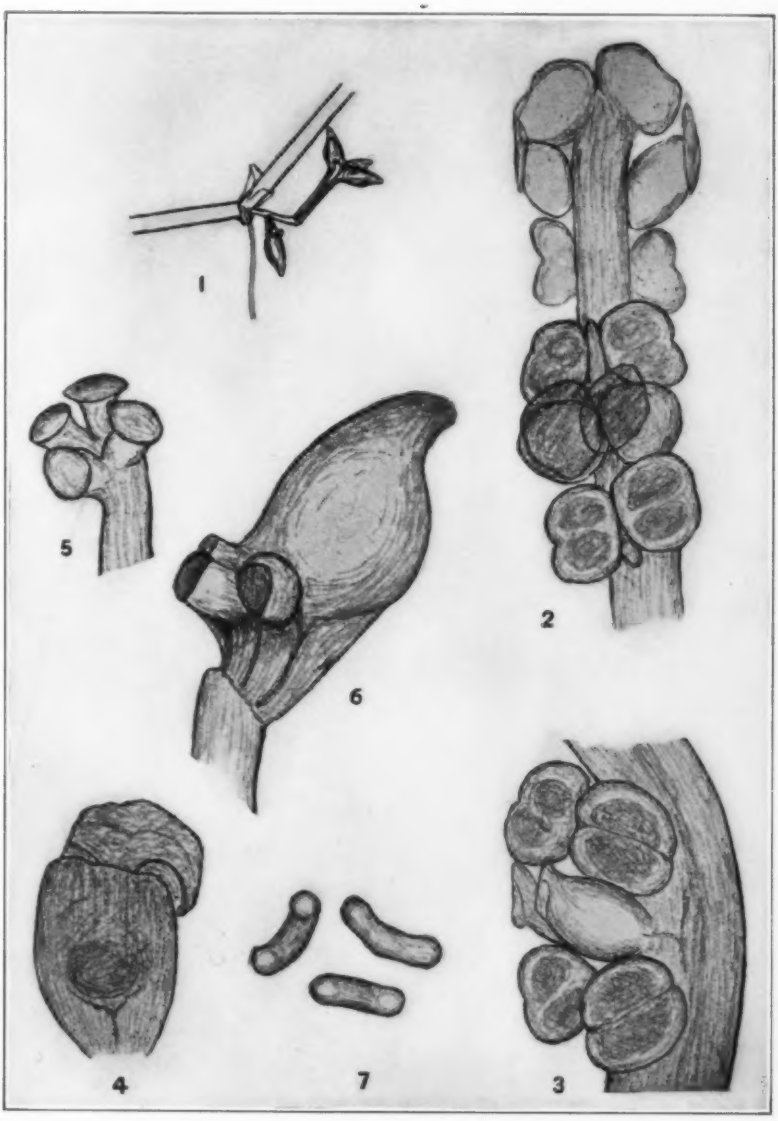

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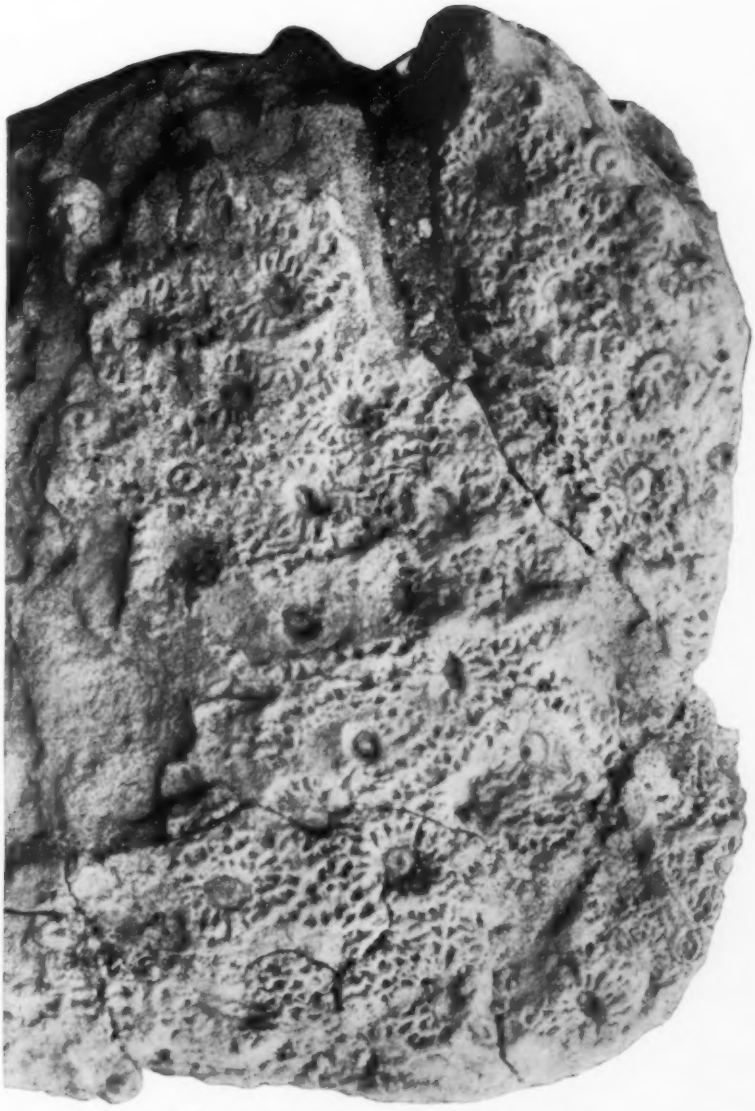

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